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Understanding Stone Test Reports of Group C Marbles

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Editor's note: Vincent R. Migliore served as the MIA's Technical Director from 1997-2003. This article on Group C Marbles was the last article Mr. Migliore wrote for the Marble Institute, intended to heighten awareness about the Marble Classification System. Following his death in the fall of 2003, the MIA has established the Migliore Lifetime Achievement Award, as well as the Migliore Natural Stone Education Scholarship in his memory.

As the dimension stone industry has matured, scientific methods are used increasingly to determine the suitability of specific types of stone for use in particular projects. One of the principal concerns encountered in the industry about these methods is a difficulty to understand stone test reports issued by testing labs.

In this bulletin, we'll review an example of a typical lab report about a specimen of Group C marble,[1] then follow it with a brief explanation of what it means in terms of practical application. Group C marbles, as well as the other marble groups, A, B, and D, are tested according to ASTM International standards.[2]
A typical report on a Group C marble may read as follows:

Findings:
Lithologic Classification: Fossiliferous Limestone

Textural Data: Finely crystalline, anhedral, tightly interlocked calcite and dolomite, with a mean crystal diameter (calcite matrix) of approximately 4 to 5μ, a maximum crystal diameter (calcite and dolomite cement) of 0.54 mm, and a mean allochem grain diameter of approximately 0.13 mm.

Thin-Section Fabric: The stone specimen is characterized as a fine to very fine crystalline, yellow-brown to tan-colored, densely interlocked, extensively burrow-mottled and locally fractured dolomitic and fossiliferous limestone. It is classified as an ostracod-mollusk-sponge lime packstone/wackestone, using the Dunham Classification System. The limestone is variably grain- and/or matrix-supported and exhibits a relatively dense concentration of poorly preserved and extensively recrystallized skeletal debris dispersed through a groundmass of lime mud. Large burrow molds, locally outlined by sinuous (stylolite-like) concentrations of organic-rich clay matrix material, are common throughout the sample framework. A significant amount of solution-enhanced intercrystalline porosity is associated with the sinuous matrix lenses. Very finely crystalline dolomite is common as a replacement for portions of the calcite matrix.

Allochem Grain Constituents:
Ostracods (small marine crustaceans)
Mollusk shell fragments and spines
Sponge skeleton spicules
Foraminifera (marine protozoans)
Undifferentiated, poorly preserved skeletal debris.
Echinoderm plates and spines (skeletal remains of marine animals such as starfish and sea urchins)

Cements and Matrix Constituents. The calcite comprising this stone is generally tightly interlocked and locally replaced with dolomite cement. Minor amounts of clay matrix materials and goethite ($Fe2O3 \cdot H2O$) cement and organic matter are concentrated with the sinuous lenses of matrix that locally outline the burrow molds.

Pore Systems: The limestone specimen exhibits a moderate amount of solution-enhanced intercrystalline porosity in association with the matrix lenses previously described. Total porosity exhibited in the thin-section

sample is visually estimated to account for approximately 2 to 3% of the bulk volume; however, the void space is well interconnected with the burrow mold outlines.
The C97 report indicates that this stone weighs 165.4 pounds per cubic foot and has an average absorption rate of 0.94%.
The C241 report indicates that the stone has an abrasion resistance of 18.4.
C97 and C241 requirements are as follows:

Test	**Density Requirement**	**Absorption Requirement**	**Abrasion Resistance Requirement**
C503 (marble)	162.0	0.20	10.0
C568 (limestone)	160.0	3.00	10.0

End of Findings:
Fossiliferous limestone contains fossils. Typically, the stone is burrow-mottled (burrowing organisms have left holes) and locally fractured (limited fractures permeate the stone at the burrow holes).

A relatively dense concentration of poorly preserved and extensively recrystallized skeletal debris is dispersed through a groundmass of lime mud. Large burrow molds, locally outlined by sinuous (stylolite-like) concentrations of organic-rich clay matrix materials, are common throughout the sample framework. There are pieces of shell fragments in a bed of lime mud. Large, curved holes in the limestone are evidence of once-living marine creatures that have become fossilized. These fossils are well distributed and heavily concentrated in the stone.

This fossiliferous limestone specimen exhibits a moderate amount of solution-enhanced, intercrystalline porosity. The holes are large enough for water to travel through. The void space is well interconnected; the holes in the stone connect and form long tubes.

In most instances, the C97 and C241 tests are used without an examination of the structure of the stone. The results for the stone indicate compliance with the requirements of ASTM C503 and C568 for tests C97 and C241. The geological examination indicates that there will be problems if this stone is used in a wet or exterior area, or a floor-on-grade installation without a protective membrane.

What does all of this mean? The fossiliferous limestone specimen was formed of lime mud that has partially metamorphosed into calcite. There are tubes in the stone that are mostly dolomite. The remainder of the stone is silty mud consisting of calcite and shell fragments. The calcite and dolomite are the sections of the stone that have metamorphosed. The stone is extensively microfractured.

This kind of stone will be a maintenance problem because water used to clean it will penetrate to the silt, which expands when it absorbs water. If fossiliferous limestone is installed in a floor on grade without a membrane, water will percolate through the stone. The stone will decay from efflorescence caused by the contact with moisture; thus, the amount of water used in the installation bed should be limited. Grout used with this stone must bond well to the edge of the stone and be sufficiently hard to prevent water from percolating through it. The grout joint should be wider than normal to ensure protection against percolation.

Fossiliferous limestone should not be used in wet areas, or areas subject to getting wet, such as a lobby floor. The stone can be used for tabletops, interior wall covering, and novelty or art pieces. It is well suited for elevator lobby walls because its color will mask fingerprints and oils from hands. It cannot be used for any structural or exterior application.

[1]By definition, Group C marbles are limestones that have undergone partial metamorphism, and are consequently polishable. These stones have variations in working qualities, geological flaws, voids, veins, and lines of separation. They can be marketed as limestone (ASTM C568) or marble (ASTM C503) if they conform to the requirements of those standards from an engineering standpoint. But in fact, most of these stones don't conform to the requirements of ASTM C568 because they're not sound and free of visible defects or concentrations of materials that will cause objectionable staining or weakening in normal environments of use (ASTM C568.5.2).
[2]ASTM requires testing for modulus of rupture (ASTM C99) and compressive strength (ASTM C170). These tests are recommended for applications where the stone is to be used for cladding above 4 stories, or as paver of at least 1¼" thickness being installed on a sand bed or with a pedestal system. MIA standards require that the substrate being installed upon should supply all of the structural requirements necessary to bear cladding or paver stones up to 1¼" thick. Such stones are used primarily for their aesthetic appearance and abrasion resistance.

